

CERES FM1-FM4 Edition3

Radiometric Calibration

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Edition 3 Studies

1. Gain Adjustments

Incorporate all known changes in gain and other calibration coefficients for each instrument based on the on-board calibration results.

2. Beginning of Mission Spectral Response Functions

Reassess the ground calibration data and determine the spectral response function for the Shortwave and the Total sensors.

3. Set the CERES instruments on the same radiometric scale at mission start

Develop the methodology to place all CERES instruments on the same rad. scale.

4. Determine optimal Spectral Response Function to correct for the on-orbit degradation in Shortwave region

Direct comparison approach is used to correct the change in the SW sensors.

Regression on the Day-Night differences of Longwave and Window measurements on each instrument is used to correct for the degradation in the shortwave region of total sensor.

Gain Adjustments

The in-flight gain changes were determined using the on-board Blackbody sources and the SWICS.

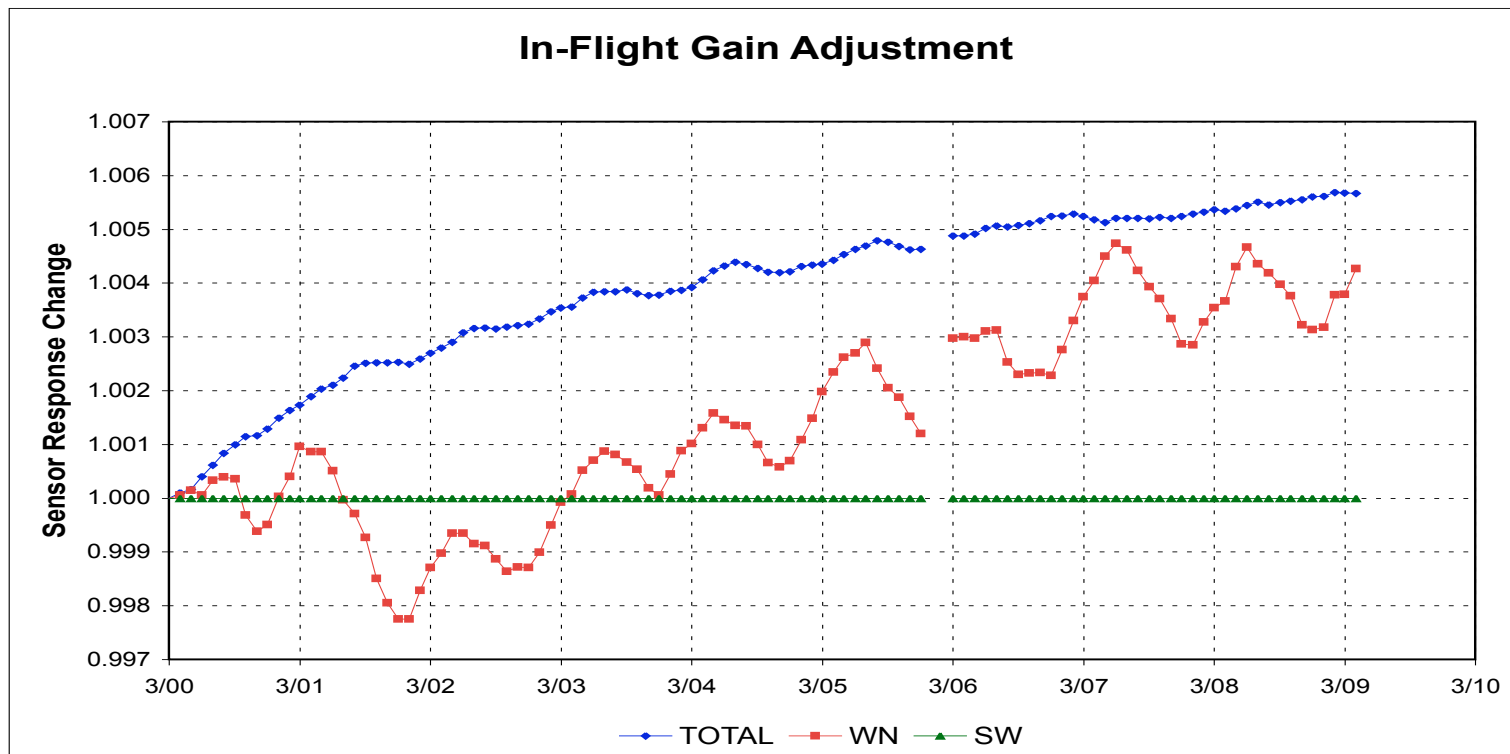
The monthly variation in the total and window sensor gains were reduced with a five month running mean approach.

The Blackbody and SWICS calibration data collected during ground testing were reevaluated and incorporated for the ground to flight changes in the sensor gains.

CERES FM1 GAIN CORRECTIONS

Ground to Flight Sensor Response change :

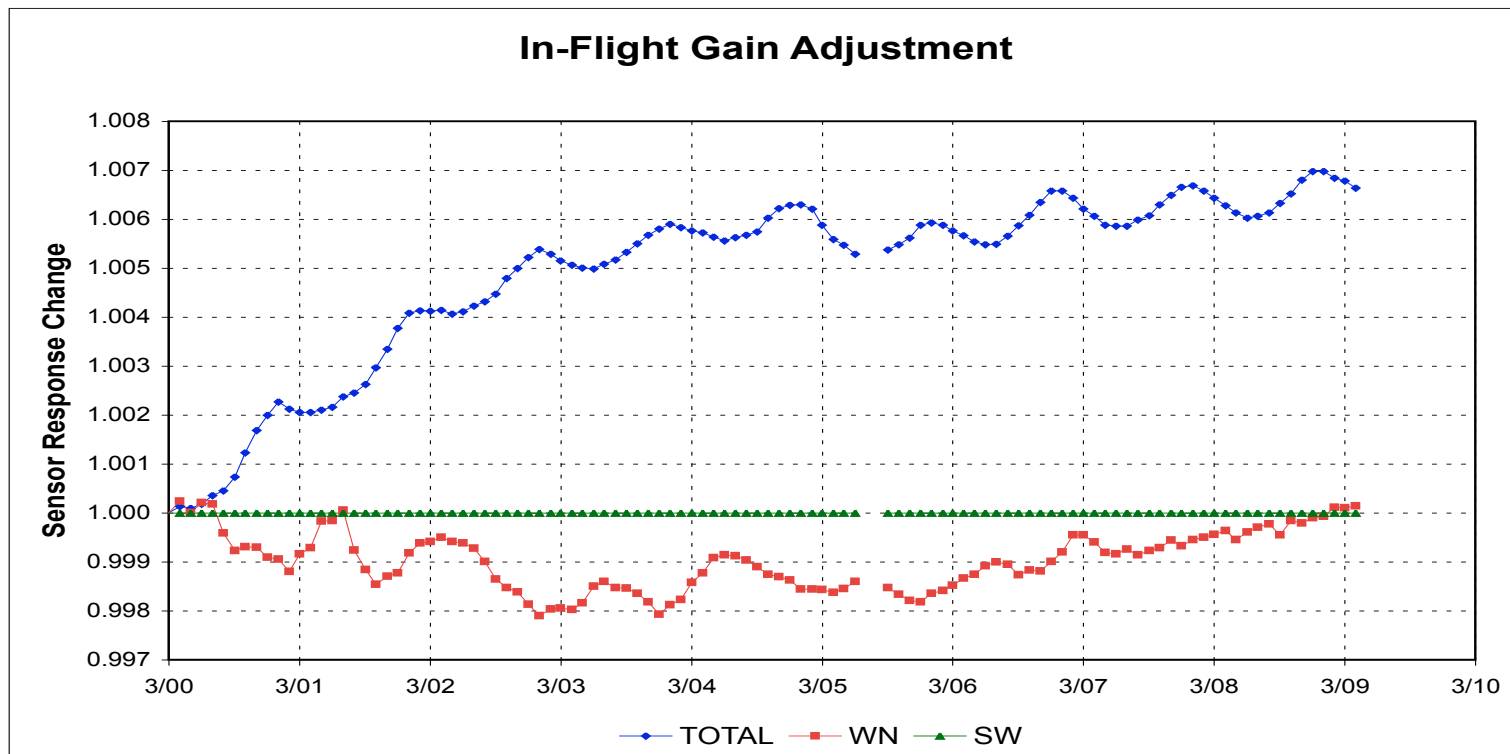
Total	Window	Shortwave
0.989	1.004	0.995
-1.1%	+0.4%	-0.5%



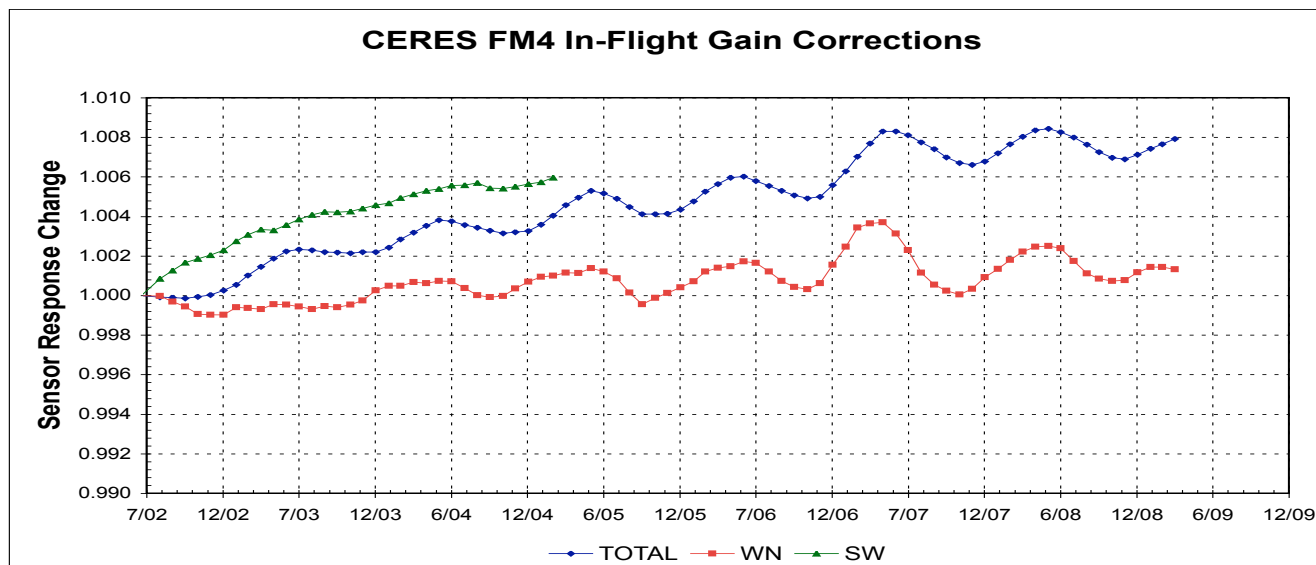
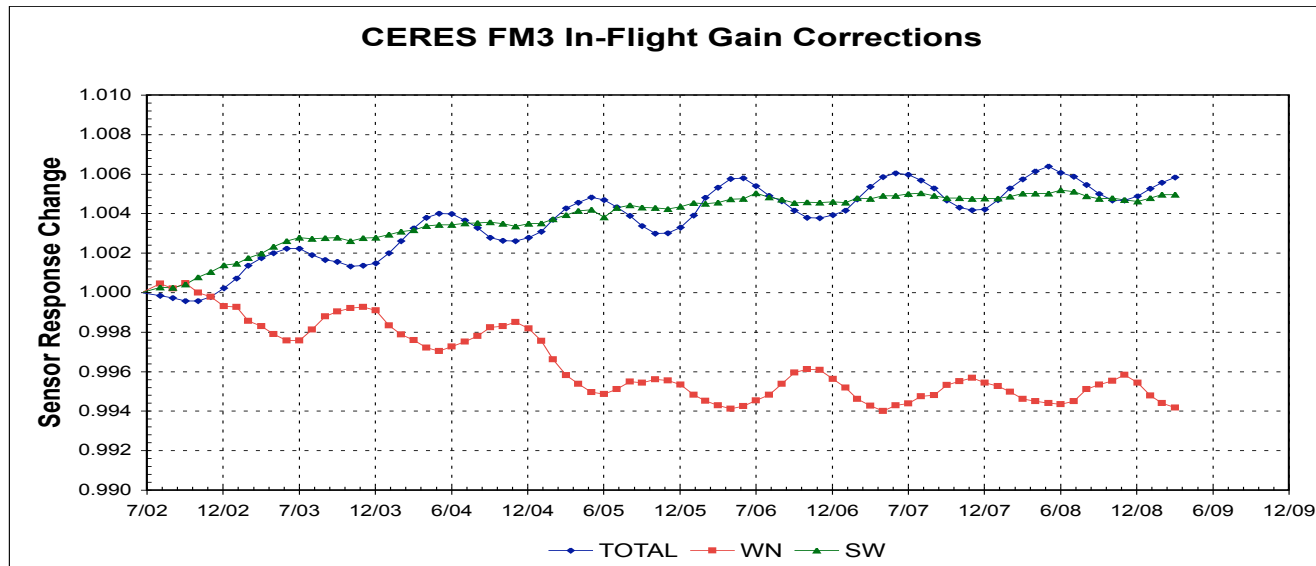
CERES FM2 GAIN CORRECTIONS

Ground to Flight Sensor Response Change:

Total	Window	Shortwave
0.9888	1.0161	0.9999
-1.12%	+1.61%	-0.01%



AQUA: CERES FM3 & FM4 GAIN CHANGES



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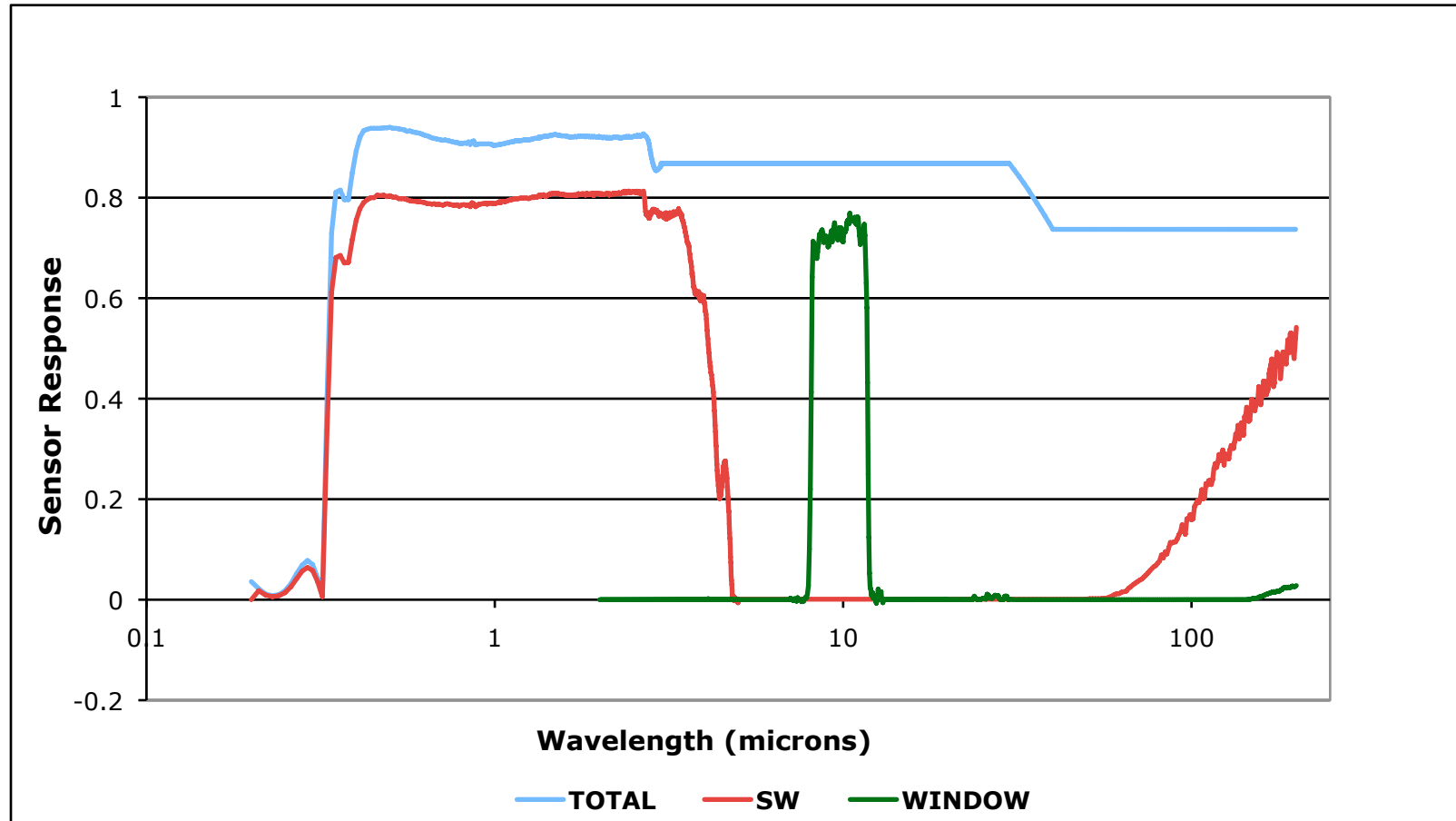
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CERES Spectral Response Function

FM1 Edition2 - Start of Mission



Spectral Response Function Evaluation

Measurements from the pre-launch test data were re-analyzed to determine the optimal Spectral Response Function (SRF) for CERES sensors.

SHORTWAVE REGION:

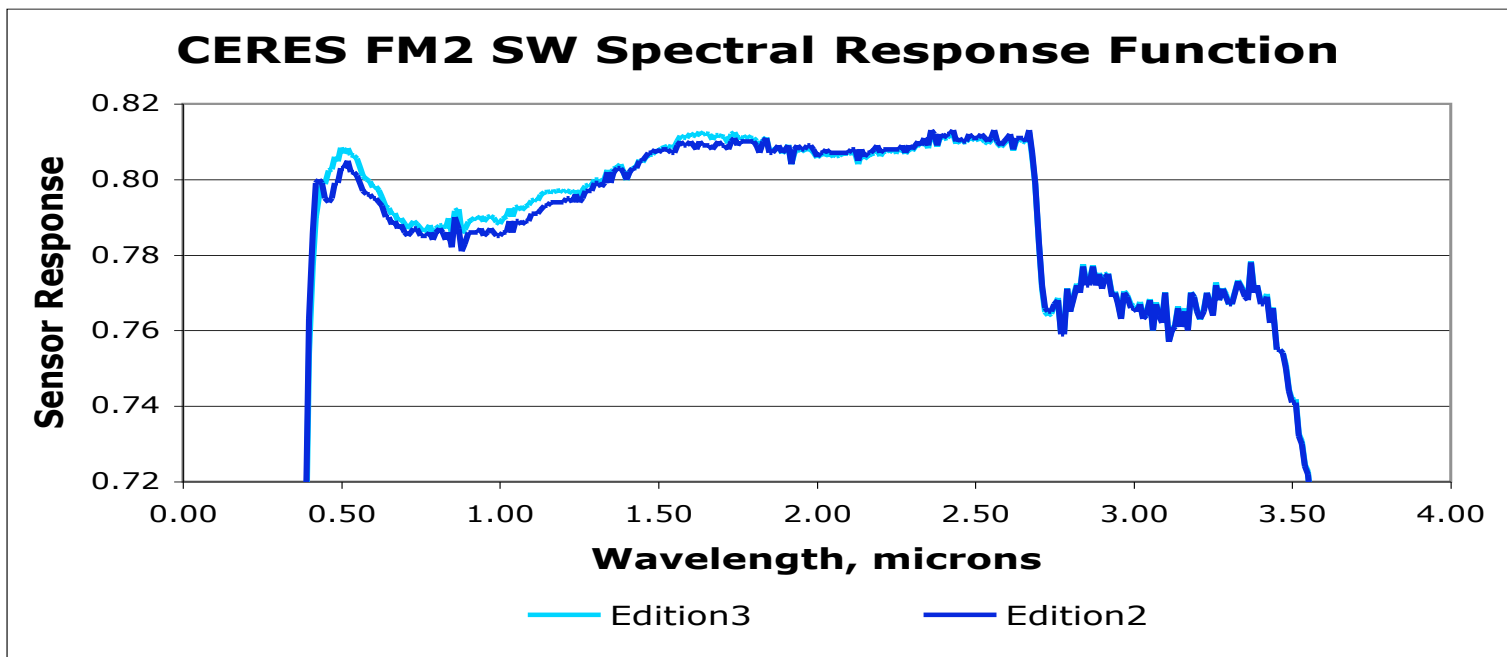
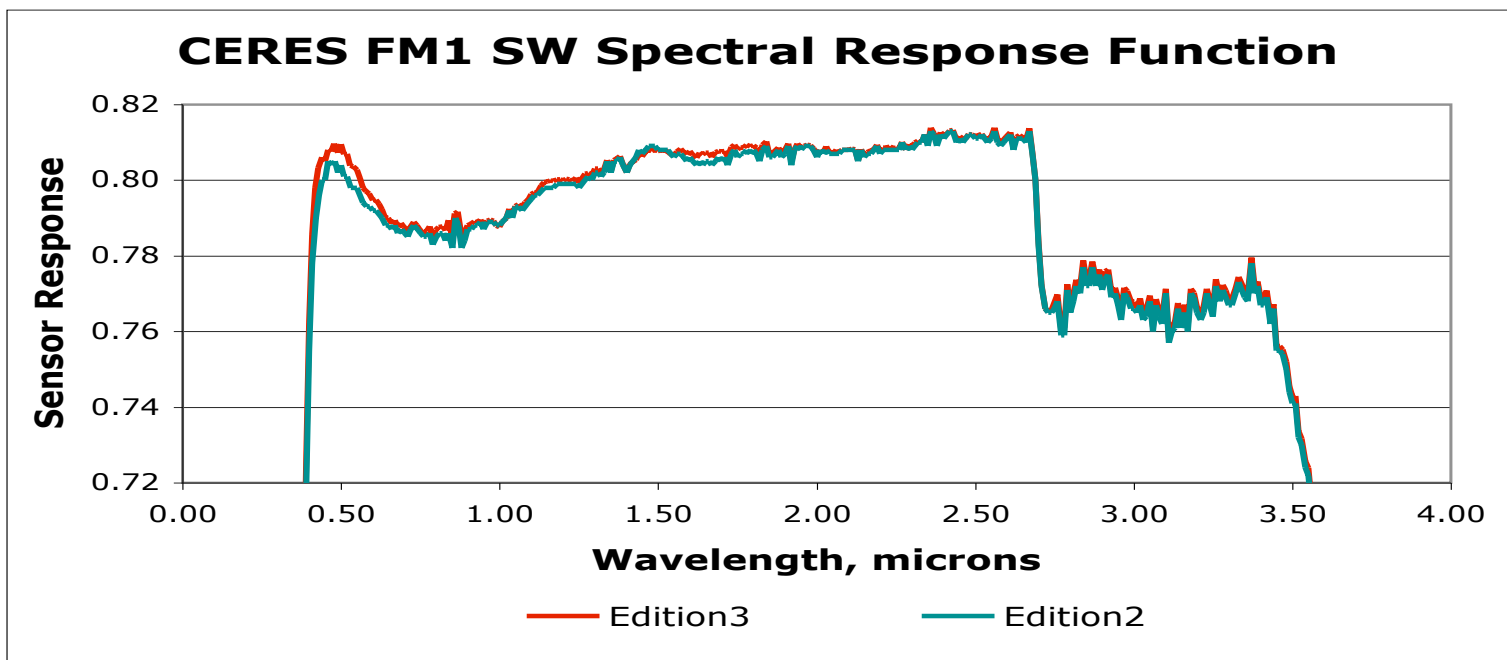
Component measurements re-evaluation: Silver data from different coating runs.

Impact of shortwave reference source (SWRS) spectral throughput on band-pass filters used in the determination of Gain/SRF.

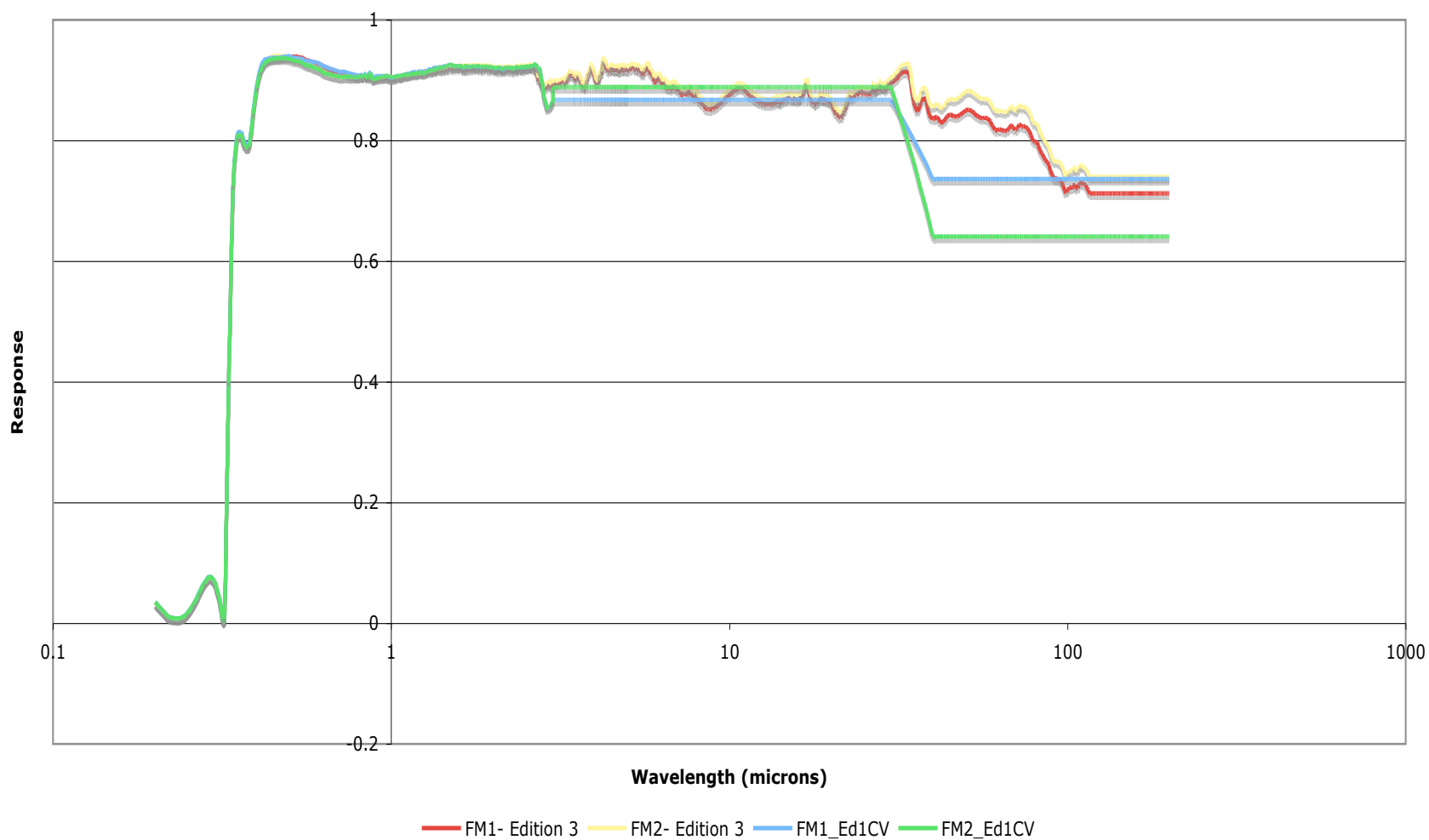
LONGWAVE REGION:

The Fourier Transform Spectrometer (FTS) measurement analysis to determine the SRF in the Longwave region.

Mohan Shankar's presentation in ADM WG will give detailed description of Spectral Response Function determination.



CERES FM1 & FM2 Total Sensor Spectral Response Functions



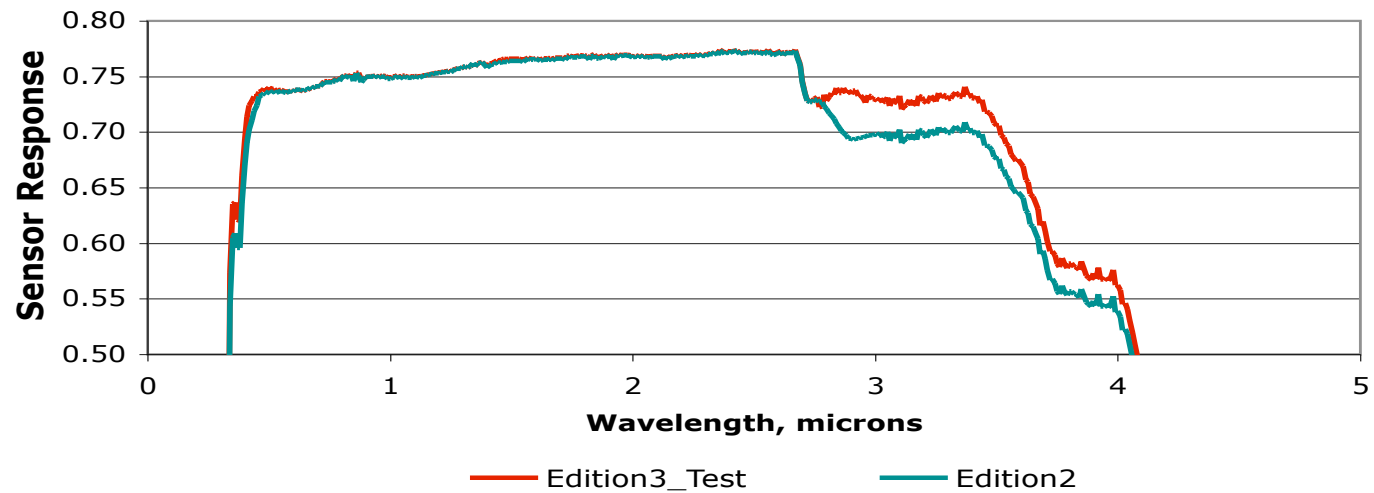
TERRA Radiance Comparison

Edition2 and Edition3 Spectral Response Function

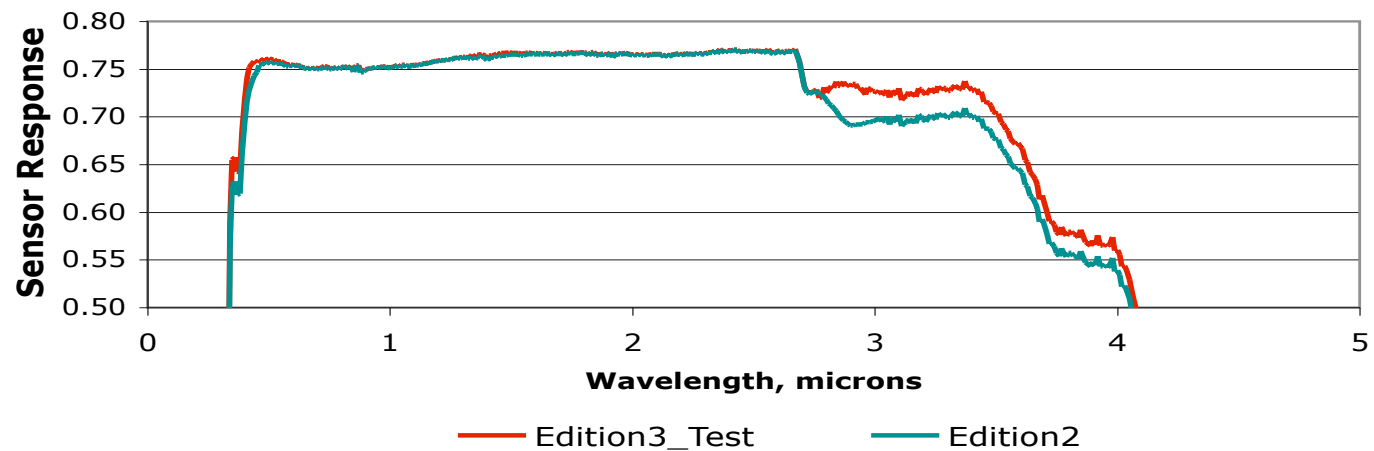
ALL SKY Global Flux Results for March 2000
based on ERBE-Like ES-8 product
NADIR data

	FM1			FM2		
	Edition3 Wm-2	Edition2 Wm-2	Ed3-Ed2	Edition2 Wm-2	Edition3 Wm-2	Ed3-Ed2
LWday	231.77	230	0.77%	231.84	230.95	0.38%
LWnite	224.61	225.28	-0.3%	223.63	224.89	-0.56%
SW	256.20	253.59	1.03%	255.52	253.48	0.8%

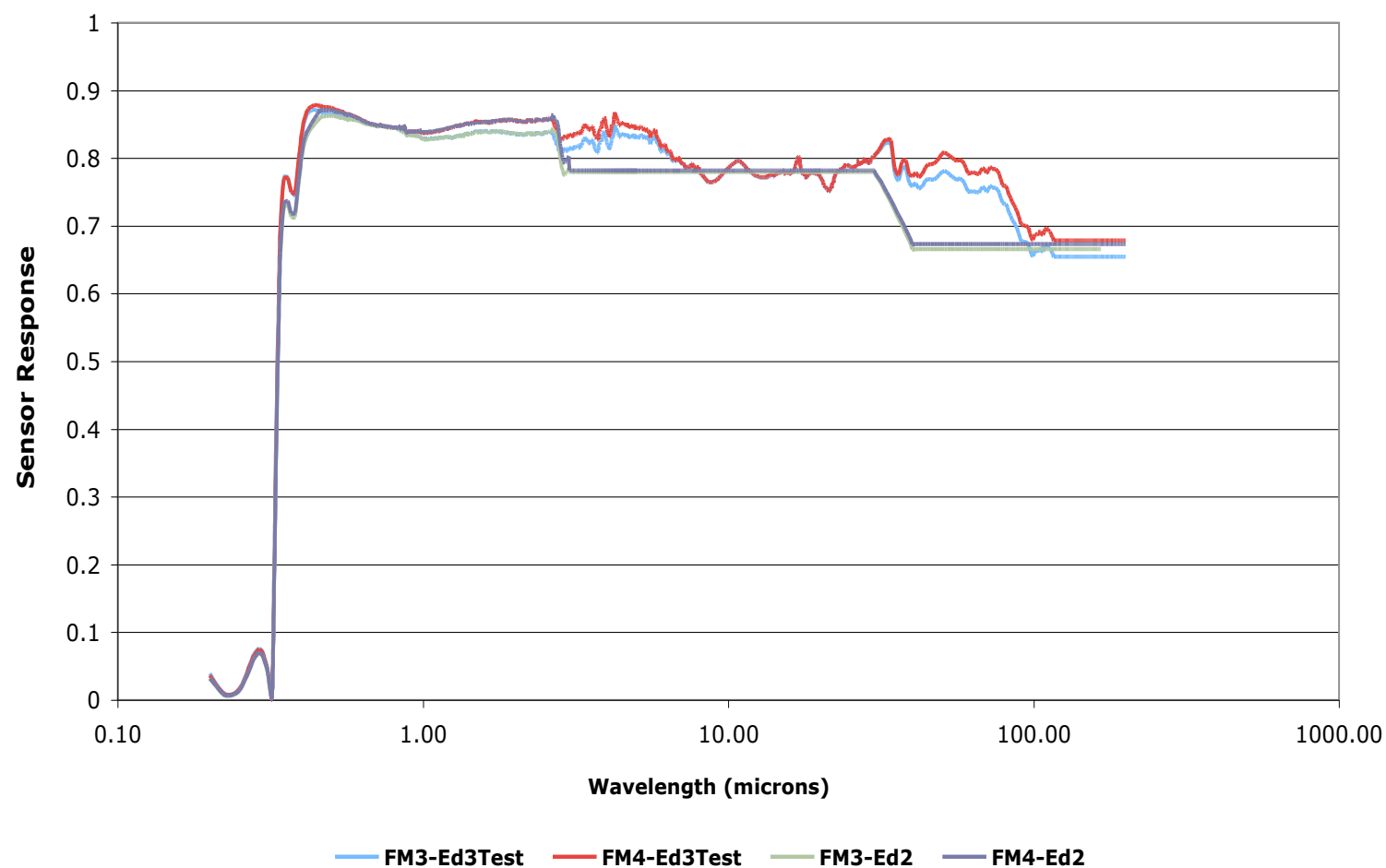
CERES FM3 SW Spectral Response Function



CERES FM4 SW Spectral Response Function



AQUA: CERES FM3 & FM4 Total Sensor Spectral Response Functions



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Placement of CERES measurements on same Radiometric Scale

- CERES measurements from 5 different instruments span 12 years (1998-2009).
 - TRMM-PFM : January – August 1998, March 2000
 - Terra – FM1& FM2: March 2000 – Present
 - Aqua – FM3 & FM4: July 2002 - Present
- The same radiometric scale at the Beginning of Mission
March 2000 for Terra and July 2002 for Aqua
- **FM1 is selected to be the climate instrument:**
 - Produces the longest, continuous data set
 - Longest in cross-track mode of operation
 - Shows the smallest spectral changes for the mission
 - Shows the best consistency for the 3-channel comparison
 - Has been used to compare with AQUA since 2002

Test to set CERES FM1 as reference

- Direct compare of CERES FM1 and FM2 based on ERBE-Like ES-8 product
 - Proposed Edition 3 data for March 2000
 - Comparison at the unfiltered radiance level
 - matched geometry of measurements for $VZA < 60^\circ$
 - 1500 comparison regions for day or night in one month
 - Averaging over $1^\circ \times 1^\circ$ grid
 - For all three channels and all scene types

Complementary Tests

- Direct compare of FM1 or FM2 and PFM:
 - The same approach as for Terra
 - Edition 2, March 2000 PFM data
 - PFM geometry matched by FM1 or FM2 (PAPS mode)
- Deep Convective Cloud (DCC) SW albedo
 - SSF data was used to define deep convective clouds
- Direct compare of FM1 and FM2 based on SSF
 - Clear Ocean (CLRO) and DCC subsets
 - Near nadir measurements
 - Imager information in selecting matched footprints
- Direct compare of Terra footprints at nadir (ES8)

Required shifts for the Terra Instruments at Beginning of Mission

- Direct compare and other tests show satisfactory consistency, and statistically significant differences (@ 2 sigma level) in the 3 channels:
- Adjustments to the CERES FM2 Measurements
 - Shortwave (SW) should be raised by 0.22%
 - LW_day should be decreased by 0.05%
 - LW_night should be raised by 0.4%
 - Window (WN) should be raised by 0.45%

Z. Peter Szewczyk presentation in the ADM WG will cover the intercomparison study in detail.

Edition 3 Calibration Summary

1. Gain Adjustments

The gain changes for Terra Instruments from March 2000 – Dec 2004 were delivered for production. The gains from Jan 2005 – Mar 2009 are being validated. The radiometric gain changes for the Aqua Instruments were derived.

2. Beginning of Mission Spectral Response Functions

The evaluation of Spectral Response Functions for Terra Instruments were completed and delivered.

The BOM Spectral Response Functions for Aqua Instruments are currently under testing.

3. Set the CERES instruments on the same radiometric scale at mission start

CERES FM1 instrument is selected as the standard instrument.

The comparison studies between FM1 and FM2 instruments were completed.

The correction values to bring Terra instruments on the same radiometric scale were derived.

Edition 3 Studies

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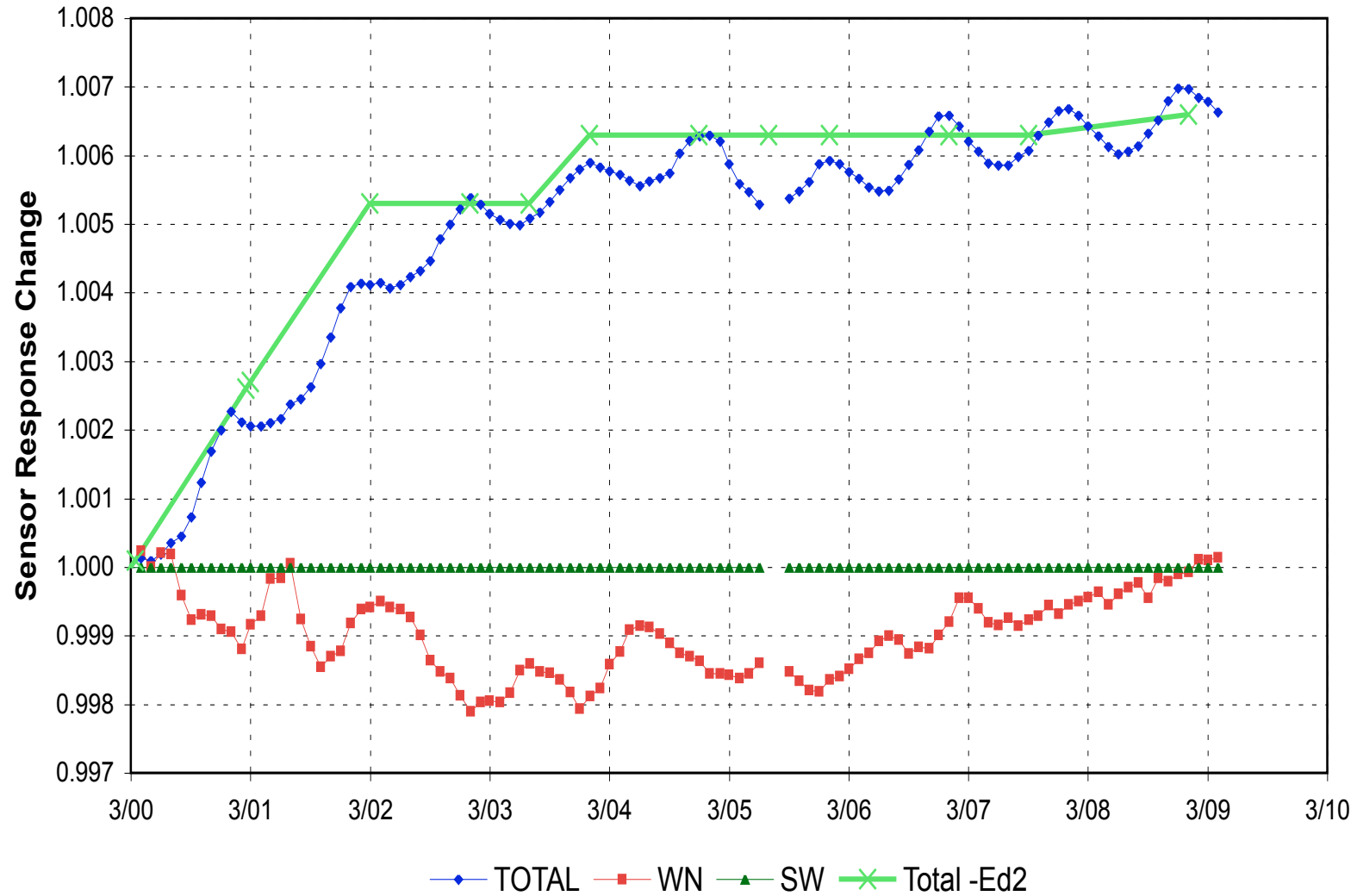
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BACK UP SLIDES

CERES FM2 In-Flight Gain Adjustment



CERES FM1 & FM2 Comparisons

Results based on All-sky (ES-8 product)

FM2 Radiance (Wm-2)	Radiance Difference (FM2-FM1)	Difference % change
73.73	0.04	0.05
70.24	-0.23	-0.4
72.72	-0.16	-0.22
5.14	-0.02	-0.47
4.81	-0.02	-0.47

TRMM – TERRA Comparisons

FM1-PFM Results for All-Sky scene

Unfiltered Radiance	μ FM1	$\Delta\mu$	$\frac{\Delta\mu}{\mu}$
LW_day	85.69	-0.08	-0.10
LW_night	80.98	-0.46	-0.56
SW	73.63	0.20	0.28

FM2-PFM Results for All-Sky scene

Unfiltered Radiance	μ FM2	$\Delta\mu$	$\frac{\Delta\mu}{\mu}$
LW_day	85.59	-0.04	-0.05
LW_night	80.57	-0.78	-0.97
SW	70.93	-0.24	-0.34

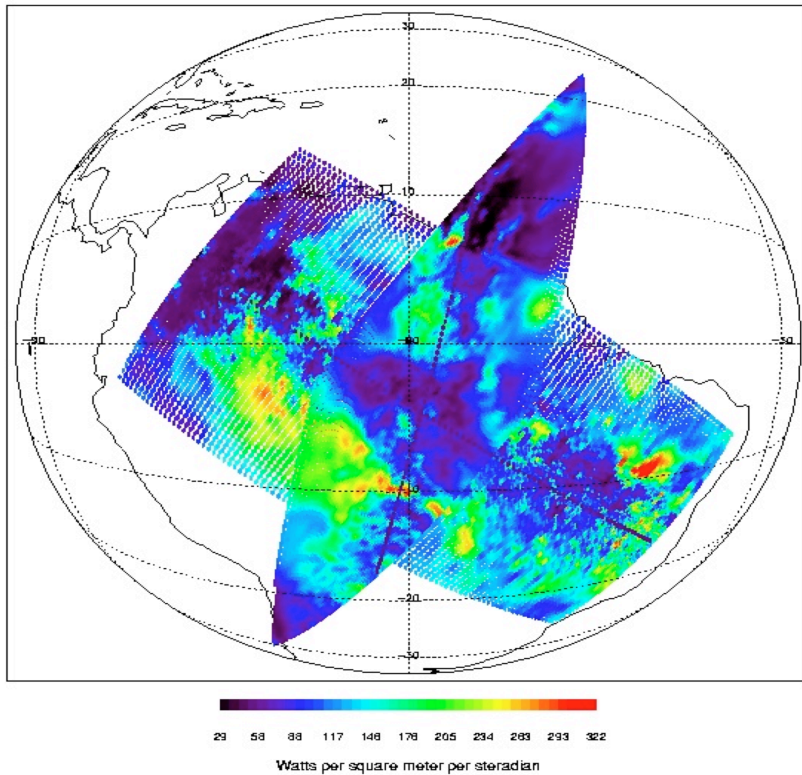


Figure 6. PFM and FM1 scanning patterns during an orbital crossing; their relative azimuth angles coincide.

SSF DCC based SW Albedo

TERRA FM1-FM2 Comparison:

FM1 and FM2 albedo results from matched footprints are 0.721 and 0.720 respectively.

TRMM – TERRA Comparison:

PFM, FM1 and FM2 albedo results are 0.709, 0.705 and 0.7 respectively.

FM1 Three Channel Comparison

	Daytime Nadir slope (fSW vs. Delta LW)
Edition1-CV	-0.0208
Edition-3	-0.0036